AIR FORCE OFFICE of SCIENTIFIC RESEARCH [AFOSR]
Manager of the Basic Research Investment for the Air Force

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Research HIGHLIGHTS

Plasmon Waveguide

For nearly 400 years scientists have peered into their optical microscopes and been able to see microorganisms, but nothing much smaller. Thanks to a recent Air Force Office of Scientific Research-funded effort at the California Institute of Technology, their eyes have been opened to smaller possibilities.

The breakthrough is the result of the creation of "the world's smallest wave-guide, called a plasmon waveguide, for the transport of energy in nanoscale systems" by Dr. Harry Atwater and his associates. They have created a sort of "light pipe" that's made of a chain-array of dozens of microscopic metal slivers that allows light to skip along the chain. In the past, scientists had been limited by the basic nature of light that distorts images of objects much smaller than the wavelength of the light that illuminates those objects. This had prevented their ability to make and use optical devices smaller than the wavelength.

With such technology, scientists can now sidestep this longstanding barrier and potentially create optical components that possess numerous technological applications.

"What this represents is a fundamentally new approach for optical devices in which diffraction is not a limit," Atwater said.

With the nanoscale device era rapidly approaching, Atwater noted, the future bodes well for extremely tiny optical devices that, in theory, would be able to connect to molecules, and someday, individual atoms.

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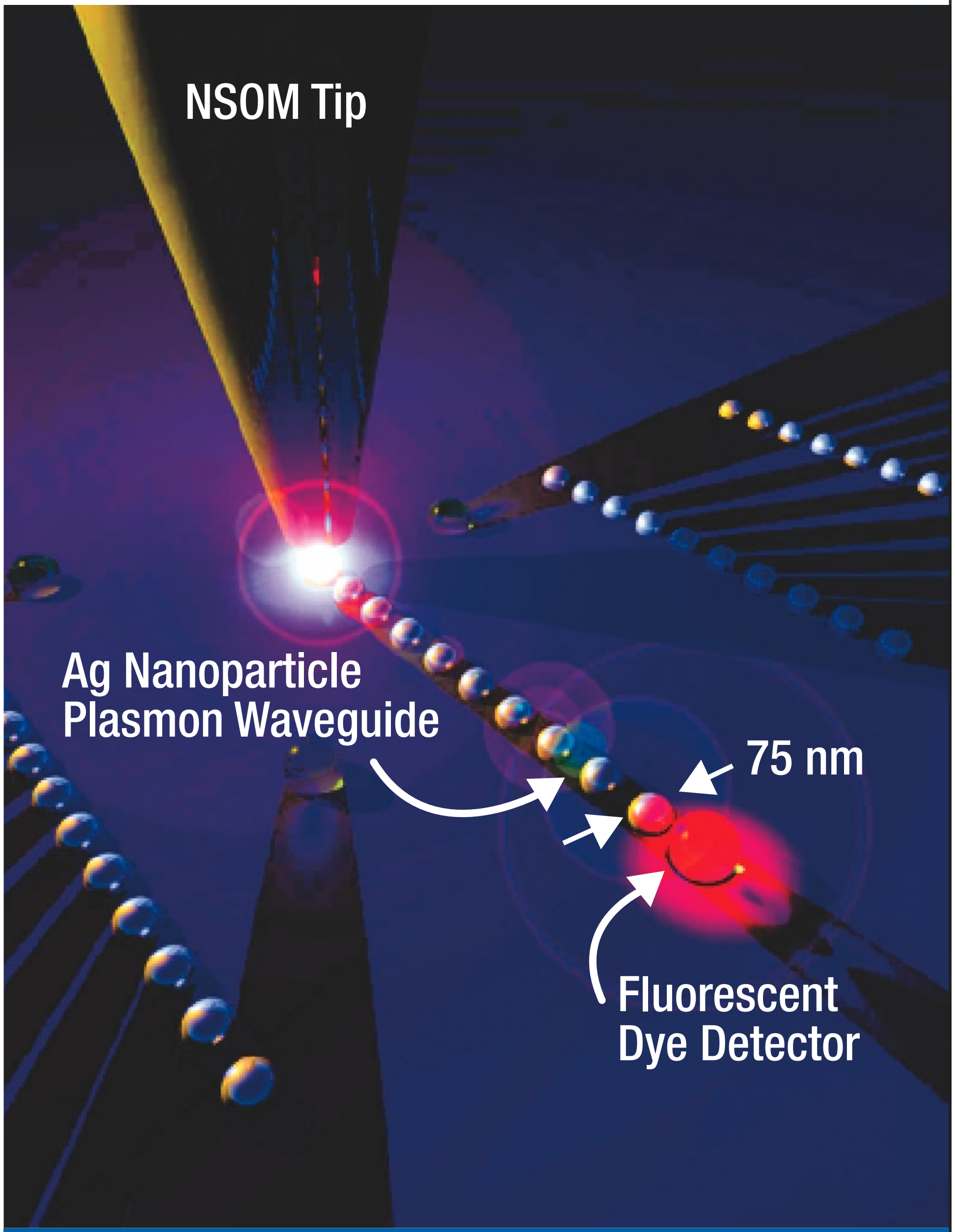
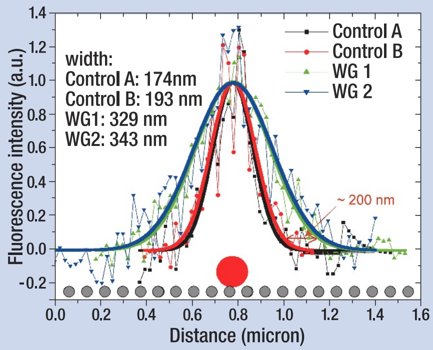


The "world's smallest" waveguide consists of a linear chain array of particles spaced to enable optical transport between particles.

Plasmon Waveguide



ABOVE: An Ultrasmall Waveguide: Subwavelength Scale Plasmon Waveguide. Dyes on waveguide excited over a waveguide distance of ~500 nm.

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Currently, Atwater's team's "plasmon waveguide" looks similar to a glass microscope slide. Fabricated on the glass plate by means of electron beam lithography is a series of nanoparticles, each about 30 nanometers (30 billionths of a meter) wide, about 30 nanometers high, and nearly 90 nanometers long. These etched "rods," arranged in a parallel series like railroad ties, have such a miniscule space between them that light energy is able to move along with little radiated loss. Thus, the light is confined to the smaller dimensions of the nanoparticles themselves. The light energy then "hops" between the individual elements in a process known as dipole-dipole coupling, multiplying at a rate considerably slower than the speed of light in a vacuum.

Aside from being tiny optical waveguides, these structures also are useful in detecting biomolecules. Therefore, a virus, or even a single molecule of nerve gas, conceivably could be detected with an optical device designed for sensing biological warfare. The ultra-small waveguide could also be used to optically interconnect to electronic devices, because individual transistors on a microchip are too small to be seen in a conventional optical microscope.

In addition to the AFOSR's Physics and Electronics directorate, the research also was supported by the National Science Foundation.

Dr. Gernot Pomrenke, AFOSR/NE
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Breakthroughs in Group III Nitrides

Significant advances in semiconductors has attracted worldwide attention thanks to important research by Air Force Office of Scientific Research (AFOSR)-funded scientists.

This semiconductor research in Group III Nitrides, such as GaN (Gallium Nitride), is being conducted at several institutes in Korea and Japan, in conjunction with the Air Force Research Laboratory's (AFRL) Materials and Manufacturing directorate.

Researchers have discovered that Group III-Nitrides are not only promising candidates for solid-state lighting, but they possess excellent physical and electrical properties that allows them to operate in harsh environments.

Due to a widespread increase in Asian research in the area of Nitride semiconductors, the Asian Office of Aerospace Research and Development (AOARD) began sponsoring initiatives with several institutions in the continent to address efficient device performance. AFOSR managers capitalized on tapping into the burgeoning field, especially in Korea and Taiwan, largely because of the astounding achievements of a single researcher, Dr. Shuji Nakamura, the world's foremost expert in nitrides. Nakamura, formerly of Japan, is a professor at the University of California at Santa Barbara (UCSB).

While Nakamura was the first to successfully establish the means for growing crystalline GaN layers for devices, many characteristics of nitrides remain unclear. This is because the world lacks a viable GaN substrate upon which to grow high-quality crystal lattice-matched structures and subsequently fabricate high-performance devices.

That was until Korea's Samsung Advanced Institute of Technology (SAIT) found an effective alternative substrate or "template" upon which to grow good material. These lattice-matched structures characterize and optimize important material system parameters. It has allowed AFRL researchers to understand and thereby minimize the performance-limiting defects that plague these materials.

Cooperation between the Meijo University in Japan and Arizona State University resulted in a special growth technique combining the use of (LT) interlayers with a grid-patterned substrate. The combination, if thick enough, results in epitaxial layers forming an effective "substrate." As a new idea, it's promising as a nitride epitaxial growth and substrate candidate.

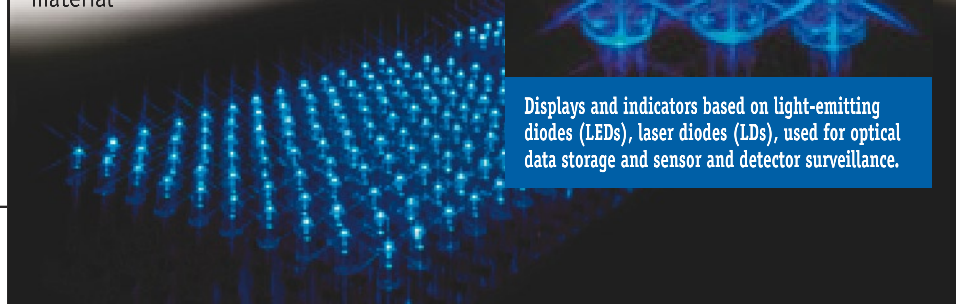
Other improved nitride material projects involve collaborations between Japanese researchers at Tsukuba University and UCSB Professors Steven DenBaars and Shuji Nakamura. Since 1996, this U.S.-Japan team has worked together to champion the basic physics and preparation of GaN crystal layers.

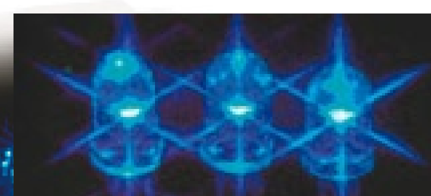
Another effort to understand and ultimately control defects is the collaboration between Science University of Tokyo (Ohkawa) and UCSB (Nakamura). This partnership establishes the interfacial physics involved in the chemistry of nitrides, particularly how nitrides behave in chemical reactions.

Scientists predict that devices based on these materials will have numerous Air Force and DoD applications and an enormous impact on high-power radars, such as those employed on remote-sensing platforms. Other applications include displays and indicators based on light-emitting diodes, laser diodes for optical data storage, and sensor and detector surveillance systems such as the solar-blind shield and biological agent detectors.

Dr. Joann Maurice, AFOSR/AOARD

Dr. Charles Lee, AFOSR/NL





Displays and indicators based on light-emitting diodes (LEDs), laser diodes (LDs), used for optical data storage and sensor and detector surveillance.

University Nanosat Program

The idea seemed simple enough. Call upon the finest collegiate aerospace minds across the country to design and build a nanosatellite, provide those selected with approximately $100,000, encourage them to team with people in industry, and have them compete for the honor of having their creation launched into space.

That was 1999, the year the inaugural University Nanosat Program (UNP) was launched. The results, according to Dr. Gerald Witt, were simply "outstanding."

Witt, an Air Force Office of Scientific Research's Physics and Electronics program manager, reported that the first UNP produced three nanosats — small satellites with a mass of approximately 10 kilograms — that completed the NASA safety reviews. They are currently awaiting placement on a Space Shuttle launch manifest, tentatively expected around September 2005.

The program was so successful, Witt added, that AFOSR — along with the Air Force Research Laboratory's Space Vehicles Directorate, and NASA Goddard Space Flight Center — announced its recent launch of UNP II. From a field of 35 university proposals, 13 were selected to compete for the honor of having their nanosat launched on the Space Shuttle as part of a joint Air Force Space Test Program and NASA venture.

Among those universities selected were: Arizona State University, University of Colorado, University of Hawaii, Michigan Technological University, University of Michigan, Montana State University, New Mexico State University, the Pennsylvania State University, University of Texas, Washington University and Worcester Polytechnic Institute. Each was granted about $100,000 from AFOSR and given two years to produce a viable nanosatellite.

The universities will then present their nanosatellites to a panel of esteemed judges from the American Institute of Aeronautics and Astronautics. The nanosats, according to Witt, will be evaluated in three major categories: student participation, technical relevance and its ability to fly. Compliance with NASA safety requirements also will be factored.

Witt said the creation of a workable nanosatellite is only one of the benefits the UNP offers.

"The quality of education students receive from this program is incredible," he insisted. "Students have the opportunity to get actual hands-on training in researching, designing, redesigning, building and testing a nanosatellite. You won't get that from a book."

The program also yielded another positive, yet unexpected benefit, according to Witt.

"Six of the students who graduated from the last program went on to work with us in the Science and Technology program," he explained. "Three were hired by the Air Force Research Laboratory and three went to work for NASA."

Throughout the contest period, the AFRL Space Vehicles Directorate and NASA Goddard will provide on-going support and training such as mini-courses on program and project management, spacecraft mission and the Lifecycle Design Process, and risk management and mitigation to name a few.

One factor that will contribute to the success of each university's UNP program will be their ability to establish space industry partnerships. These partnerships could provide key funding, mentoring and experience to the students participating in this program.

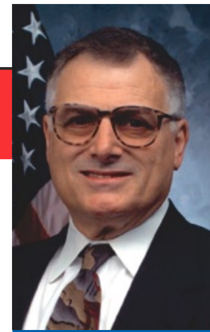
"Strong university-industry ties, in addition to the ties with the Air Force and NASA, are important parts of the program," said Witt.

Dr. Gerald Witt, AFOSR/NE

ABOVE: Montana State University students (left to right) Justin Whisenhunt, Jesse Parker, Dax Levandoske, and Aaron Hall with their BalloonSat payload at the Student Hands On Training (SHOT) workshop.

BELOW: Arizona State University students Lauren Egan, William Forstie, Michael Gonzalez, and Imani Randolph with their balloon payload at the SHOT workshop in Boulder, Colorado.

AWARDS: Dr. Lyle H. Schwartz


Dr. Lyle H. Schwartz

In a career teeming with accomplishments, Dr. Lyle H. Schwartz can now add "Honorary Membership" to ASM International to an already impressive list.

The Society for Materials Engineering and Scientists, which boasts nearly 40,000 members from 100 countries, selects just one honorary member each year.

"I'm feeling quite honored at the moment," reflected Schwartz, the director of the Air Force Office of Scientific Research who received his doctorate of philosophy in materials science from Northwestern University. "It will be very special for me to see my name listed with those outstanding contributors to my field. They were my heroes as I first entered professional life."

Dr. Schwartz was recognized by ASM for his innovative and effective leadership in planning, prioritizing and administering materials research and development within the federal government and industrial/government partnerships. As AFOSR's director, Schwartz leads a staff of more than 150 scientists, engineers and support people in Arlington, Va., and two foreign technology offices in London and Tokyo.

He is charged with maintaining the technological superiority of the Air Force. The society also honored Dr. Schwartz for his outstanding work in x-ray and neutron diffraction, Mossbauer spectroscopy, and for service to ASM International.

Honorary membership in the materials information society was established in 1919. It recognizes distinguished service to the materials science and engineering profession, to ASM International and to the progress of mankind.

"Honorary membership is among the most prestigious awards of the society," noted an ASM international spokesperson. "Consequently, it is expected that all nominees will be truly outstanding individuals who have significantly furthered the purposes of the society through an evidenced appreciation of the importance of the science of materials and through distinguished service to the materials science and engineering profession and the progress of mankind."

The award will be presented to Dr. Schwartz in October 2003 in Pittsburgh, Pa.

Research Highlights

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Research Highlights is published every two months by the Air Force Office of Scientific Research. This newsletter provides brief descriptions of AFOSR basic research activities including topics such as research accomplishments, examples of technology transitions and technology transfer, notable peer recognition awards and honors, and other research program achievements. The purpose is to provide Air Force, DoD, government, industry and university communities with brief accounts to illustrate AFOSR support of the Air Force mission. *Research Highlights* is available on-line at:

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